TECHNOLOGY USES IN MICHIGAN SCHOOLS: AN EMPIRICAL STUDY[1]

Yong Zhao, Ph. D
Ken Frank, Ph. D

College Of Education
Michigan State Univeristy
Center For Information Development[2]
Michigan Technology Implementation Project (Mtip)
A Program Funded By The Michigan Department Of Education

November 30, 2001

Contact information: Dr. Yong Zhao, 115D Erickson, College of Education, Michigan State Univeristy, East Lansing, MI 48824, Email: zhaoyo@msu.edu, Phone: 517-353-4325

[1] This study was made possible by a grant from the Michigan Department (MDE) of Education, but views and findings expressed in this report are not necessarily those of MDE. The following individuals participated in the design and implementation of this study: Yong Zhao, Ken Frank, Blaine Morrow, Kathryn Hershey, Joe Byers, Rick Banghart, Andrew Henry, and Nancy Hewat. Although we cannot identify the names of the schools that participated in this study, we want to thank all the teachers and administrators in these 19 schools. Without their cooperation and support, this study would not have been possible.

[2] The Center for Information Development research conducted at Michigan State University was directed by Dr. Yong Zhao, Associate Professor of Educational Technology, College of Education, Michigan State University.

Executive Summary

The purpose of this study was to assess technology uses and understand what might affect the level and type of technology uses in schools. Given this purpose, we needed schools that had technology available to teachers and students. Thus we only selected schools that had made a significant investment in technology for at least five years. A total of 19 elementary schools in four districts participated in this study. Our data suggests that the districts included in this study had more access to technology than the national average in terms of students to computer ratio. We also compared our samples with other schools in the same state on other background variables. Students attending the sampled schools seemed to come from higher income families than the average in terms of percentage of students qualified for free or reduced cost lunch. However, analysis suggests that the sampled schools were not significantly different from other schools on other measures such as per pupil expenditure, student teacher ratio, and school size.

1. The level of technology uses in these sampled schools is higher than or comparable to the national average in terms of frequency of uses. Nearly 70% of teachers reported using lab computers on a weekly or daily basis, while nearly 90% use computers in their classrooms weekly or daily. Nearly 90% of teachers reported using emails weekly or daily while over 70% use the web weekly or daily.
2. However when the types of uses are considered, the situation is less encouraging. In most cases, the frequent uses are limited to teacher functions instead of student activities. For example, while over 50% of teachers reported that they use computers weekly or daily to communicate with parents and prepare for instruction, 73% of teachers reported that computers were never used for student to student communication. Nearly half of the teachers reported they never used computers for student inquiry activities. The most frequent student uses of computers are for developing basic computer skills.

3. There was significant change and anticipated change in the uses of technology. A majority of the teachers reported that their uses of computers increased significantly and plan to increase even more in the future.
4. Teachers' technology using experiences both in the lab and classroom have been positive. The majority (over 75%) reported that they experienced some technical problems in less than 25% of the times they used computers. And over 60% of the teachers said that these problems were addressed in an acceptable time frame.
5. In general, teachers were positive about computers and did not feel intimidated by computers. About 85% of the teachers felt that they could learn new computer applications quickly and over 50% thought computers are flexible and can be used to support their teaching style. Around 70% of teachers felt that computers can help them integrate different aspects of the curriculum, teach innovatively, direct student learning, model an idea or activity, connect the curriculum to real world tasks, and be more productive. Similarly, they believed that computers are valuable in helping students develop new ways of thinking, think critically, gather and organize information, explore a topic more deeply, be more creative, and be more productive.
6. School organized professional development opportunities were not frequent. About 5% of teachers reported never attending and 70% reported attending only once a year district or school organized inservice programs for learning new technologies. However, many more teachers reported that they engaged in self-exploration with new technologies or district provided software monthly or weekly. It is also a common phenomenon for teachers to seek help from their colleagues.
7. While nearly 60% of teachers felt that the computer resources in their rooms were adequate for their instructional needs, only around 30% of teachers felt the resources are adequate for student uses. Similarly only one third of teachers felt it was easy to implement software or new hardware in their schools.

8. About 60% of teachers felt that they had access to sufficient and reliable hardware. A similar portion of teachers felt the same way about software. What's worth mentioning is that only a small fraction of teachers felt that schools and districts adequately involved teachers in decisions about software selection.
9. Many teachers felt the pressure to use computers. Nearly 60% of teachers reported that others expect them to use technology.
10. Of the many factors that influence teacher uses of technology, the opportunity to explore and experiment with technologies seems to be a significant one. Also important is getting help from colleagues. Another major contributing factor is teachers' perception of the compatibility between technology and their teaching practices. In other words, those teachers who believe technology can support their teaching are more likely to use computers. The introduction of too many new programs in schools seems to negatively affect teachers' use of technology. That is, when a school is trying to introduce too many new initiatives, teachers' use of technology decreases. Another very important and expected finding is that school districts play a major role in teachers' technology uses.

Table of Contents

List of Tables

TECHNOLOGY USES IN MICHIGAN SCHOOLS: AN EMPIRICAL STUDY

Introduction

Fueled by the belief that information technology can be a powerful educational too(Papert, 1993; President's Committee of Advisors on Science and Technology (Panel on Educational Technology), 1997; Roschelle, Pea, Hoadley, Gordin, & Means, 2000; U.S. Department of Education, 2000) and that students must be technologically competent in an information society (International Society for Technology in Education, 2000; Literacy, Board, & Commission on Physical Sciences, 1999), American schools have spent billions of dollars acquiring computers and related information technologies over the past two decades, resulting in a dramatic increase in the presence of technology in schools. The number of computers, for example, increased from only 250,000 in 1983 to 8.6 million in 1998 (Anderson & Ronnkvist, 1999; Becker, 2000b). The average student to computer ratio dropped from 40 to 1 in the mid eighties to 5 to 1 by the end of 2000(Cattagni & Farris, 2001). Connection to the Internet has also steadily increased. In 1994 only 35% of all public schools were connected to the Internet. By the end of 2000, the percentage of American public schools connected to the Internet has grown to 98%. In other words, virtually all schools now have some kind of connection to the Internet (Cattagni & Farris, 2001).

The investment in school technology is likely to continue and technology will become even more accessible in schools(Becker, 2000b; Smerdon et al., 2000). The question facing researchers, policy makers, and educators is thus not whether computers can improve education (Burbules & Callister, 2000; Zhao, Pugh, Sheldon, & Byers, in press), rather how and how much teachers and students make use of these expensive and potentially powerful technologies. Many studies have shown that school technologies have often been underused, both in terms of frequency and capacity (Cuban, 1986, 1996, 1999, 2001; Loveless, 1996; US Congress Office of Technology Assessment, 1995). A more recent study suggests that teachers' uses of technology have started to increase (Smerdon et al., 2000), but neither the frequency nor the type of uses has reached a level that affects education as significantly as envisioned by the proponents. In other

words in order to achieve the level of educational outcomes equal to the level of investment, technology has to be used more, more often and more connected to the core activities of teaching and learning.

What can we do to increase the frequency and improve the quality of technology uses in schools? Previous research has pointed out a long list of factors that can have an effect on technology uses in schools. First, schools have been cast as directly at odds with new technologies. The goal of schools as organizations, according to Hodas(1993), is “not to solve a defined problem but to relieve stress on the organization caused by pressure operating outside of or overwhelming the capacity of normal channels.” (p. 2) In other words, schools naturally and necessarily resist changes that will put pressure on the existing practices (Cohen, 1987; Cuban, 1986). “What appears to outsiders as a straightforward improvement can, to an organization, be felt as undesirably disruptive if it means that culture must change its values and habits in order to implement it.” (Hodas, 1993, p. 2) The introduction of computers, however, requires serious changes in the curriculum, teaching practices, reallocation of resources, and perhaps rearranging the fundamental structure of schools(Collins, 1996; Hawkins & Sheingold, 1986; Means, 1994; Merrow, 1995). Consequently schools and teachers must be less impressed by the promises of the computer delivered by its advocates. Or worse, Papert(1998) notes:

> By the triggering of something like an immune system, and I am looking at the education system as kind of a living organism, this computer that came in was a foreign body that threatened the established order of the system and like all systems this triggered a defense mechanism. (p. 3)

Besides this inherit resistance to change, schools are also said to have a structure that prevents wide spread uses of computers. Collins(1996) in his reflective essay on his experience with the Apple Classroom of Tomorrow project cites limited classroom space and the bulky size of computers, teachers' unwillingness to take the students to the lab, and access to computers at home as factors that limit the use of technology in schools. More serious problems, however, lie beyond technological or physical structures in the conceptual structure of schools.

> . . . the structure and conception of school that evolved in the last century is quite incompatible with effective use of new technologies. The view of teaching as transmission of information from teachers to their students has little place for students using new technologies to accomplish meaningful tasks. The forty-five-minute period makes it difficult to accomplish anything substantial using technology. (Collins, 1996, p. 61.)

Sharing a similar view, Papert(1999) compares the current school to a 19th century stagecoach while new technologies to a jet engine. "When they try [attaching the jet engine to the stagecoach] they soon see that there is a danger that the engine would shake the vehicle to pieces. So they make sure that the power of the engine was kept down to a level at which it would not do any harm." The structure of the school severely hampers the power of new technologies for learning (Means, 1994).

Lack of convenient access to computers, inadequate infrastructure, and poor planning are other factors identified to account for the under utilization of computers(Cuban, 1986; Smerdon et al., 2000; US Congress Office of Technology Assessment, 1995). Loveless blames computer labs for the lack of use of computers because "labs deny teachers the flexibility of deciding when technology should be incorporated into instruction, unwittingly conveying to students that computers are not central to learning and certainly not central to the activities of their classrooms." (p. 451)

A more frequently cited set of factors affecting technology uses in schools are associated with the teacher. Following the standard diffusion literature (e.g., Rogers, 1995), teachers' attitudes toward and expertise in technology has often been identified as a key factor associated with their uses of technology (Becker, 2000a; Bromley, 1998; Hadley & Sheingold, 1993; Sandholtz, Ringstaff, & Dwyer, 1997; Smerdon et al., 2000; Zhao & Conway, 1999). Teachers' working conditions, characterized by busy schedules, crowded curricula, lack of access to a professional community and support, have also been identified as important factors affecting their technology uses (Cuban, 1996; Smerdon et al., 2000). Teacher's pedagogical beliefs and

their teaching practices are also factors that seem to influence their uses of technology (Becker, 2000a, 2000b; Hadley & Sheingold, 1993; Sandholtz et al., 1997; Zhao & Cziko, 20001).

While previous studies have identified some key factors contributing to the gap between access to and uses of school technology, there are a number of conceptual and practical problems. First this body of research lacks a unifying theoretical framework to explain the relationships among these factors. In other words, we know very little from this research about how the factors interact with each other and under what conditions one factor may be more or less significant than others. For instance, if a teacher is extremely competent with information technology, does she use technology more even if she works in a conservative school? Or does she use technology more even if her teaching follows a transmission approach?

The second problem with this body of literature lies with its failure to examine the interactive process of technology uses by teachers. For example, while it is suggested that teachers' technology expertise plays an important role in teacher's uses of technology, little is known about how teachers develop such expertise. It is also unknown what levels of expertise and in what technology is more useful. Thus it has little to suggest what schools or teachers can do to improve their expertise.

The third problem is that previous research seems to only consider the utility power of technology while ignoring its symbolic value (Prasad, 1993). Technology is only considered for what it can do but not what it can mean for teachers. For instance, little is said about how technology can symbolize progressiveness and thus raises the social value of those who use technology. As a result, the introduction of technology might present great social pressure to those who do not use technology.

The last problem has to do with the failure to consider the social dynamics of the school, which is more like an ecology than community wherein the various actors—teachers, technology staff, administrators, and students—interact with each other frequently to achieve their own goals (Zhao & Cziko, 20001). Technology can either enhance or interfere with each actor's goals. For example, the use of technology may help new teachers achieve higher social status because

technology is viewed as synonymous to innovation but it may also be viewed as void of substance. Technology use is also influenced by the interplay of the existing social relationships (Bruce, 1993). Thus how the various actors in schools relate to each other and technology plays an important role in determining the level and type of technology uses.

As a result, the current study had two chief goals. First, it attempted to provide an up-to-date detailed description of current technology uses in schools. Unlike previous studies, most of which only focused on the use of computers, the current study also included the uses of other new technologies such as voice mail and telephone. This study also tried to paint a more comprehensive picture by ensuring a response rate of over 90%, from each school, thus obtaining responses from those who are most likely marginalized from the school. Second, the study intended to develop a framework for understanding the interactive relationships between the various factors believed to affect technology uses. A model was built based on the research findings.

Methodology

Research Questions

To achieve our two goals, the study sought answers to a number of questions. First we need to find out the current levels and types of technology uses in schools. Second we need to assess the current status of the various factors that have been identified as possible contributors to the uses of technology. Third we need to find out how much each factor may influence technology uses. The following table summarizes the indicators and constructs of the current study.

Table 1 Indicators and Constructs

Research Questions	Indicators/Constructs
Levels and Types of Technology Uses	Levels of Technology Uses
	Types of Technology Uses
Factors Influencing Technology Uses	Teacher Technology Proficiency
	Teacher Technology Beliefs
	Teacher Technology Professional Development
	Teacher Social Networks
	Teacher Perception of Technology Support
	Perceived Pressure for Using Technology
	Competing Innovations
	Compatibility with Teaching Styles
	District Factors

Data Collection

The study collected mainly three types of data: survey of all staff; interviews with administrators, technology staff; and selected teachers, and observations of schools. The survey included 33 various format items (e.g., Likert Scale, multiple choice, and fill in the blanks). The interviews were semi-structured loosely following a set of questions about technology infrastructure, policy, investment, and beliefs. The observations mainly focused on technology infrastructure of a building. The data collection was completed in the spring of 2001. A professional independent research firm was contracted to perform the data collection.

Sample

Because of our interest in understanding how institutional factors and social dynamics may affect technology use, we chose whole school districts as our first level of analysis. A total of four districts were selected. Since our interest was to assess technology uses and understand

what might affect the level and type of technology uses in schools, we needed schools that had technology available to teachers and students. Thus we only selected schools that had made significant investment in technology within the last five years. The criteria used to select districts for participation in the study included recent passage (within the last 2-3 years) of a bond referendum or receipt of a community foundation grant for implementation of technology, the willingness of the Superintendent of Schools to participate in the study, and the size of the district (at least three elementary schools). These were essential criteria for selection, and resulted in a school sample slightly more advantaged than the average school in the state. We were also interested in understanding possible building level differences, so we included all elementary schools in the selected districts. In order to obtain the complete picture of technology uses we administered the survey to all school staff. We offered incentives to schools for high response rates and to individual teachers to come as close as possible to enumerating the entire faculty population. Ultimately we achieved a response rate of 92% or greater in each of our nineteen schools. We selected one school from each district as the focus school where we interviewed the principal and three teachers. We also interviewed the superintendent and technology director of each district. We also observed technology use in the focus schools.

Table 2 presents background information of the sample school districts.

Table 2 Background Information of Districts

District	Students Population	District Type	Student/Computer Ratio*
A	2041	Rural/Suburban	5.1
B	5111	Suburban	4.9
C	1638	Rural-suburban	2.9
D	7158	Rural/Suburban	4.4

Note: Student computer ratio is average for all districts instructional computers as of March 2001.

These data suggest that our sample had more access to technology than the national average (Cattagni & Farris, 2001). We also compared our samples with other schools in the same state on other background variables. Not surprisingly students attending the sampled schools seemed to come from higher income families than the average in terms of percentage of students qualified for free or reduced cost lunch. However analysis suggests that the sampled schools were not substantively different from other schools on other measures such as per pupil expenditure, student teacher ratio, and school size.

Findings

The section includes three parts. Part 1 reports findings on current uses of technology, while part 2 reports measures of the various factors associated with technology uses. Part 3 presents findings of a statistical model that delineates factors that influence technology uses in schools.

Current Technology Uses in Schools

To what degree are technologies used in schools?

Table 3 presents the percentage of teacher reports of the frequency of their using common school technologies for educational or professional purposes. As Table 3 shows, the most frequently used technologies are phone systems, email, and computers in the classroom. What is interesting is that teachers use computers more in classroom than in the computer lab, which is somewhat contrary to the observation of Loevless (1997). This may be the result of recent investment in putting more and better computers in the classrooms. It could also mean that the schools and teachers we sampled are ahead of the curve in terms of access and uses of classroom computers.

What is also interesting to note is that much less research attention is paid to the phone system than to computers, and yet the phones are getting used a lot. The phone, albeit not as complex a technology as the computers, can be a powerful communication tool for the teachers. Frequent uses of the phone could transform the teacher from being isolated in the schoolhouse

(Tyack & Cuban, 1995) or classroom (Lortie, 1975) to potentially integrated with parents, colleagues, other schools, and community members. It would be interesting to know what they are using the phones for in future studies.

Table 3 Frequency of Technology Uses

	Never (%)	**Yearly (%)**	**Monthly (%)**	**Weekly (%)**	**Daily (%)**
Phone system (n=431, mean= 4.76)	0.50	0.20	2.10	16.90	80.30
Voice mail (n=428, mean= 3.72)	12.60	6.80	13.30	30.60	36.70
Video/TV network (n=427, mean= 3.4)	9.60	9.40	32.30	28.80	19.90
World Wide Web(n=427, mean= 3.96)	3.70	3.70	18.00	41.20	33.30
E-mail(n=429, mean= 4.62)	3.30	2.30	4.20	9.80	80.40
Computers in your school=s lab (n=427, mean= 3.45)	10.50	10.10	11.00	60.70	7.70
Computers in your classroom (n=411, mean= 4.57)	5.10	0.70	4.10	11.70	78.30

What Kind of Technology Uses are Teachers Engaged in?

Besides levels of uses, we asked about the types of computer uses in schools. The uses are divided into two categories: teacher uses and student uses. The overall reliability of this scale is .81. Table 4 presents the percentages of frequencies of activities using computers. As indicated in Table 4, the most frequently types of uses are communication with parents and preparation for instruction, while the least are activities directly involving students using the computers (e.g., student to student communication, remediation, student inquiry, and student expression). What is interesting is the high frequency of using computers for communication with parents but not with students. In light of teachers frequent use of the phone, we may hypothesize that teachers have a strong need to break down Lortie's walls—teachers have the need to communicate with parents and colleagues, but technology was not there when Lortie

studied the schools. Teachers infrequent use of computers for communication with students may be a explained by the fact that presently most of the communications with students take place in face-to-face in the classroom.

Table 4 Frequencis of Compter Using Activities

Activity	Never	Yearly	Monthly	Weekly	Daily
Communication with parents (e.g., newsletters, e-mail, class Web page) (n=427, mean= 3.38)	11.20	5.60	29.50	41.00	12.60
Teacher-student communications (e.g., response to written work, posting schedules and activities) (n=420, mean= 2.75)	34.00	7.90	21.40	21.90	14.80
Classroom management and/or incentives for students (e.g., reward for completed work) (n=416, mean= 2.68)	36.80	7.70	17.80	26.20	11.50
Record keeping (e.g., grades, attendance, IEP) (n=419, mean= 2.39)	48.40	7.60	15.00	14.10	14.80
Preparation for instruction (e.g., lesson and unit planning, downloading materials such as pictures) (n=420, mean= 3.57)	8.60	6.90	26.70	34.30	23.60
Student to student communication (e.g., publish student work on a Web page, keypals, e-group projects) (n=412, mean= 1.54)	73.30	8.00	11.20	6.10	1.50
Student inquiry (e.g., student research using electronic databases, WebQuest) (n=413, mean= 2.17)	42.10	13.10	31.20	12.60	1.00
Student expression (e.g., Hyperstudio, PowerPoint collections of artwork, KidPics, i-movies) (n=413, mean= 2.32)	35.10	18.40	28.30	15.50	2.70
Core curriculum skills development (e.g., drill and practice on MathBlaster or Reader Rabbit) (n=416, mean= 2.96)	26.20	3.60	29.60	29.10	11.50
Remediation (e.g., repeat a lesson, Accelerated Math, Jostens) (n=406, mean= 2.42)	47.50	4.40	18.00	19.00	11.10
Development of basic computer skills (e.g., keyboarding, mouse skills, trouble shooting) (n=412, mean= 3.02)	27.40	4.10	15.30	45.10	8.00

Changes in Computer Uses

The study also tried to understand if teachers' of computers change over time. We asked teachers to indicate to what degree their uses of computers changed over the previous year and to what degree they plan to increase or decrease their uses of computers. Table 5 summarizes the responses of changes over the past year. A majority of teachers (84%) reported that they used computers more or much more than the previous year and they intend to use more in the future (see Table 6).

Table 5 Changes in Computer Uses from Previous Year

	Much less	**Less**	**Same**	**More**	**Much more**
n= 428, mean= 4.16	0.00	1.40	13.80	52.10	32.70

Table 6 Intended Uses in the Future

	Much Less	**Less**	**Same**	**More**	**Much more**
World Wide Web (n=424, mean= 3.9)	0.50	0.50	20.30	66.30	12.50
E-mail (n=425, mean= 3.55)	0.50	0.00	54.10	35.30	10.10
Computers in your school's lab (n=418, mean= 3.34)	1.20	1.00	64.40	29.40	4.10
Computers in your classroom (n=411, mean= 3.75)	0.70	0.00	32.60	57.20	9.50

World Wide Web and computers in the classroom are the two areas where teachers intend to increase their uses the most. This is a healthy trend as these uses have perhaps the greatest educational potential. They directly affect student learning and instruction.

Quality of Computer Using Experiences

Besides levels and types of uses, the study investigated the quality of computer uses by teachers, both in their own classrooms and in the school labs (see Tables 7 and 8). As indicated in Tables 7 and 8, teachers' experience of using computers seemed to be positive, at least in terms of the percentages of times they encountered problems and how quickly the problems were solved.

Table 7. Quality of Computer Using Experiences in the Lab

	Percent of Times Experiencing Technical Problems	Percent of Times Self-solving the Problems	Percent of Times Asking for Help	Percent of Times Problems Solved in Acceptable Time
(1) <25%	74.30	48.60	27.40	7.40
(2) 25%-50%	18.40	17.30	25.30	13.90
(3) 51%-74%	4.20	14.40	15.80	15.50
(4) 75% or more	3.10	19.70	31.60	63.20

Table 8 Quality of Computer Using Experiences in the Classroom

	Percent of Times Experiencing Technical Problems	Percent of Times Self-solving the Problems	Percent of Times Asking for Help	Percent of Times Problems Solved in Acceptable Time
(1) < 25%	75.50	37.60	29.90	7.90
(2) 25%-50%	16.10	24.40	26.90	16.40
(3) 51%-74%	5.70	16.20	14.30	14.10
(4) 75% or more	2.70	21.90	28.90	61.50

Factors Affecting Technology Uses in Schools

This part reports findings on factors that have been previously identified to have a possible impact on school technology uses. We start with factors associated with the teacher.

Attitudes toward and Experiences with Technology

The study assessed teachers attitudes toward technology, their self-efficacy about technology, and to what degree they perceive themselves as innovators. As Table 9 shows, teachers are generally hold a positive attitude toward technology, believe that technology can compliment their current teaching, and think they are able to learn computer technology.

The finding that teachers view themselves as innovators and hold positive attitudes toward technology is consistent with recent studies(Becker, 2000a; Zhao, 1999) but contradicts with the general belief that teachers are reluctant to use technology or anxious about learning technology(US Congress Office of Technology Assessment, 1995; Worthington & Zhao, 1999). Given the high response rate, we can safely assume that this response is not only from those who are committed to using technology but also from those who are not necessarily technology advocates. It has been suggested that teachers' attitude toward technology, particularly their perception of the degree to which technology supports their current pedagogical practices, influences their uses of technology(Becker, 2000b; Zhao et al., in press).

Table 9 Teacher Attitudes toward Computers

	Strongly Disagree	**Moderately Disagree**	**Slightly Disagree**	**Slightly Agree**	**Moderately Agree**	**Strongly Agree**
a)I try new things in the classroom (n=423, mean= 5.18)	1.20	2.10	1.90	13.00	35.90	45.90
b)I can work with computers effectively (n=431, mean= 4.65)	3.00	4.60	3.20	25.10	41.10	23.00
c)Computers support what I try to do in the classroom (n=417, mean= 4.53)	3.10	4.10	8.20	29.00	32.90	22.80
d)I am intimidated by computers (n=429, mean= 2.55)	35.20	20.00	14.20	18.40	8.90	3.30
e)Computers distract students from learning what is essential (n=423, mean= 1.89)	49.60	29.30	9.00	8.00	2.10	1.90
f)I am one of the first to try something new in the classroom (n=414, mean= 3.90)	6.00	11.40	20.80	23.40	25.60	12.80
g)Computers are flexible (n=427, mean= 4.52)	1.90	4.70	8.90	28.60	36.10	19.90
h)I have the ability to learn new computer applications (n=430, mean= 5.33)	0.20	1.20	2.10	10.70	33.00	52.80
i)It is easy to integrate computers with my teaching style(n=419, mean= 4.28)	3.30	8.10	13.80	25.50	29.80	19.30
j)I can recall how to perform tasks on the computer(n=431, mean= 4.66)	1.20	4.40	7.40	22.50	43.20	21.30
k)I enjoy introducing something new in the classroom (n=420, mean= 5.28)	1.2	.2	2.1	11.4	36.0	49.0
l)Learning computers takes too much time (n=427, mean= 2.74)	25.80	24.60	16.60	19.70	9.80	3.50

Beliefs about Technology

Teacher's view of the specific value of technology also affects their use of technology. Tables 10 and 11 present teachers' beliefs about how technology may be helpful to their own professional activities and student learning. Again we see that teachers hold much hope for the potential value of technology for both teachers and students, which is also consistent with previous studies(Becker, 2000b; Zhao, 1999).

Table 10. Values of Technology for Teachers

Computers can help *me*...	**Strongly Disagree**	**Moderately Disagree**	**Slightly Disagree**	**Slightly Agree**	**Moderately Agree**	**Strongly Agree**
a)integrate different aspects of the curriculum (n=425 , mean= 4.83)	2.40	2.40	1.90	28.90	32.50	32.00
b)teach innovatively (n= 425, mean= 4.91)	1.20	2.10	2.40	26.60	34.10	33.60
c)direct student learning (n= 422, mean=4.67)	1.70	2.60	5.70	30.30	36.50	23.20
d)model an idea or activity (n= 426, mean= 4.85)	2.10	1.90	4.50	22.80	37.60	31.20
e)connect the curriculum to real world tasks (n= 424, mean= 4.96)	1.40	1.90	3.10	20.80	38.40	34.40
f)be more productive (n= 430, mean= 5.03)	1.60	2.10	3.30	16.50	37.90	38.60

Table 11. Values of Technology for Students

Computers can help *students*...	**Strongly Disagree**	**Moderately Disagree**	**Slightly Disagree**	**Slightly Agree**	**Moderately Agree**	**Strongly Agree**
a)develop new ways of thinking (n=428 , mean= 4.92)	0.90	2.60	2.60	22.40	40.20	31.30
b)think critically (n= 429, mean= 4.75)	1.90	2.30	4.90	26.60	38.70	25.60
c)gather and organize information (n= 429, mean= 5.46)	0.20	0.50	0.90	8.20	31.90	58.30
d)explore a topic (n= 430, mean= 5.67)	0.20	0.00	0.50	3.50	23.50	72.30
e)be more creative (n= 429, mean= 4.94)	1.90	2.80	4.20	20.30	32.40	38.50
f)be more productive (n= 430, mean= 4.98)	0.70	1.20	4.70	20.50	38.80	34.20

Teacher Professional Development

The types and frequency of professional development activities related technology is also considered a factor influencing teacher technology uses. Table 12 presents how frequent teachers are engaged in what type of professional development activities. The most common professional activities are self-exploration and seeking help from others, but even these occur only monthly for most teachers. The least common forms of professional development are reading professional journals, technology manuals and attending conferences. Thus teachers have engaged in learning experiences that many believe are appropriate for learning computer technology (Sandholtz & Ringstaff, 1996; Zhao et al., in press).

Table 12. Professional Development Activities

Activity	Never	Yearly	Monthly	Weekly	Daily
a)Explore new technologies on my own (n= 428, mean= 2.99)	4.90	23.80	42.80	24.30	4.20
b)Attend district or school in-service programs for new technologies (n= 421, mean=2.19)	5.50	70.50	23.80	0.20	0.00
c)Experiment with district-supported software(n= 425, mean= 2.69)	11.50	27.30	44.90	13.40	2.80
d)Seek help from others to learn about new technologies (n= 426, mean= 2.88)	2.80	25.60	53.80	16.00	1.90
e)Attend professional-development conferences about new technologies (n= 427, mean= 1.78)	30.40	61.10	8.40	0.00	0.00
f)Read professional journals about new technologies (n= 429, mean= 1.63)	53.80	31.20	13.10	1.90	0.00
g)Consult technology manuals (n= 427, mean= 1.83)	41.50	37.50	18.00	3.00	0.00

Teacher Perceptions of Ease of Implementation

The degree to which technology is easily implemented depends on teachers' perceptions of access to adequate resources, technology and their own teaching context. Table 13 summarizes teachers' perceptions of the extent to which technology can be used implemented in their teaching. The overall finding is that teachers do not feel strongly that it is easy to use technology in their teaching. They do feel that their resources are adequate, more than they perceive that they themselves are able to implement new technology. This sounds a modest vote of confidence for the districts that are providing the technology.

Table 13. Teacher Perceptions of Ease of Implementing Technology

	Strongly Disagree	**Moderately Disagree**	**Slightly Disagree**	**Slightly Agree**	**Moderately Agree**	**Strongly Agree**
a)The computer resources in my room are adequate for my instructional needs (e.g., lesson and unit planning, accessing materials such as pictures) (n= 415, mean= 4.33)	10.60	8.70	8.00	12.80	29.40	30.60
b)The computer resources in my room are adequate for student uses (e.g., student research, writing, artwork) (n= 408, mean= 3.27)	22.80	17.40	13.00	15.20	20.10	11.50
c)It is easy to implement new software in this school (n= 411, mean= 3.56)	15.10	13.10	14.60	25.10	22.40	9.70
d)It is easy to implement new hardware in this school (n= 404, mean= 3.44)	16.80	12.90	16.80	24.00	22.00	7.40

Perception of District Support

The level of district support also influences technology uses, according to the literature(Zhao et al., in press). Tables 14 shows how teachers perceive district support in the area of hardware and Table 15 depicts their perceptions of district support in terms of software. It is encouraging to see that the majority of teachers feel positive about their district's involvement in both hardware and software. One area that teachers feel ambivalent is involving teachers in the decision making process in choosing software.

Table 14. District Support: Hardware

	Poor	Fair	Neutral	Good	Excellent
a)Providing enough hardware (n= 426, mean= 3.64)	5.40	15.70	14.60	38.30	26.10
b)Choosing appropriate hardware (n= 425, mean= 3.80)	4.20	8.00	15.80	47.30	24.70
c)Providing a reliable server (n= 425, mean= 3.60)	4.70	11.50	20.90	44.50	18.40
d)Updating hardware (n= 423, mean= 3.63)	4.30	13.90	18.90	40.20	22.70
e)Providing technical support for hardware use (n= 427, mean= 3.52)	8.90	13.30	15.70	40.70	21.30

Table 15. District Support: Software

	Poor	Fair	Neutral	Good	Excellent
a)Providing enough software (n= 426, mean= 3.37)	9.60	16.70	16.90	40.60	16.20
b)Choosing appropriate software (n= 423, mean= 3.52)	5.90	13.50	21.00	42.30	17.30
c)Updating software (n= 421, mean= 3.39)	8.10	14.50	22.30	40.10	15.00
d)Engaging teachers in decisions about software purchases (n= 424, mean= 2.77)	21.00	17.70	31.60	23.10	6.60
e)Providing professional development for software use (n= 425, mean= 3.14)	14.10	21.20	17.40	30.80	16.50
f)Providing technical support for software use (n= 427, mean= 3.26)	12.40	16.40	17.80	39.10	14.30
g)Recognition for technological innovation (n= 418, mean= 3.36)	9.30	13.90	26.80	31.60	18.40

Social Dynamics of Technology Uses

As mentioned earlier in this article, technology use is affected by and affects the school social climate. So the study attempted to assess how technology may affect a teacher socially. Table 16 describes teachers perceptions of the social climate related to technology uses in their schools. The pattern is that in most cases, teachers feel the pressure to use technology.

Table 16. Social Dynamics of Technology Use

	Strongly Disagree	**Moderately Disagree**	**Slightly Disagree**	**Slightly Agree**	**Moderately Agree**	**Strongly Agree**
a)Using computers helps a teacher advance his/her position in this school (n= 421, mean= 3.43)	17.30	11.60	14.70	29.90	19.70	6.70
b)Others in this school are critical of teachers' uses of computers (n= 427, mean= 2.08)	44.50	23.00	17.80	10.50	2.80	1.40
c)I need to use computers to keep up in this school (n= 429, mean= 4.13)	7.90	7.90	12.80	24.50	28.00	18.90
d)Others in this school expect me to use computers (n= 429, mean= 4.58)	4.90	5.40	6.10	23.50	31.20	28.90
e)My colleagues use computers more than I do (n= 428, mean= 3.49)	14.00	14.30	21.70	20.80	17.10	12.10
f)We introduce many new things in this school (n= 427, mean= 4.76)	.70	2.10	8.40	24.40	37.90	26.50
g)It is difficult to implement all of the new things in this school (n= 424, mean= 4.19)	2.80	11.10	13.00	29.50	24.80	18.90

What Factors Influence Technology Uses: Building a Model

This section presents two models that explored the relationships among the various factors and identified factors that significantly affect technology uses. Model one tries to locate the factors that affect teacher's technology uses while the Model two attempts to describe factors that influence the uses of technology by students.

In each case we have tried to organize the factors according to an overall theoretical model. That model contains: the structural context of the teacher (e.g., grade level, subject, district membership), characteristics of the teacher (e.g., orientation to teaching), relationship of teacher to technology (technical capacity/expertise, perceived value of computers), social context (perceived pressure to use computers, capacity to get help to use computers), and opportunities to learn about computers (experimentation, district in-service, etc). These factors can be affected by the multiple levels of schools. Emerging from the most remote regions, societal institutions not formally affiliated with any government level can affect teacher's beliefs about the value of technology. States and the federal government can support hardware and provide small amounts of training. Districts also can support hardware and software and are more likely responsible for training and opportunities to learn. Finally, teachers interact with one another, can help one another or exert social pressure on one another within he school. Factors from each level coalesce to influence teacher attitudes and competencies and the adequacy of resources that then affect use.

Table 17. Model of Factors Influencing Student Use of Computers

	Standardized Coefficients	Sig	B	Std. Error	t	R2
› Received						.508
WRKCHELP help from colleagues	**.100**	.011	.0079	.003	2.557	
WRKNCHEL help from non- colleagues in District and school	.042	.325	.0017	.002	.986	
loring Technology Uses						.499
Q22A explore new technologies on my own	.054	.254	.0502	.044	1.142	
Q22B attend district or school in-service programs for new technology	.068	.130	.1122	.074	1.516	
Q22C experiment with district-supported software	**.192**	.000	.1734	.045	3.881	
Q22D seek help from others	.076	.085	.0843	.049	1.725	
Q22E attend professional development conferences about new technology	.013	.770	.0188	.064	.292	
Q22F read prof journals about new tech	.075	.108	.0819	.051	1.610	
Q22G consult technology manuals	-.026	.578	-.0263	.047	-.557	
:eived Pressure to Use Computers						.431
PRESCOMP pressure to use computers (q26c,q26d)	.047	.259	.0305	.027	1.132	
efs About Value of Computers						.427
HELPME perceived value of computers for teacher (q20)	**.104**	.075	.0976	.055	1.786	
HELPSTU perceived value of computers for students (q21)	-.030	.575	-.0334	.060	-.562	
ınical Capacity/Expertise						.418
ISOLVE teacher solves technical problems on own (q5,q11)	.040	.313	.0329	.033	1.010	
OUTHELP amount of help provided to others	.025	.537	.0070	.011	.619	
›vation Competition						.403
Q26F We introduce many new things in this school	**-.116**	.005	-.0940	.033	-2.820	
:her=s orientation						.401
COMPLEM computers complement teaching style (q19 c-e+g+i)	**.117**	.026	.1058	.047	2.242	
ctural Location						.307
District D	.192	.004	.3268	.112	2.908	
District B	.095	.137	.1838	.123	1.491	
District A	.197	.000	.4786	.128	3.745	
Q27EN1 teach English	**.248**	.000	.4519	.091	4.988	
GRADE grade teacher teaches	**.192**	.002	.0739	.024	3.138	
MULTGRAD teaches multiple grades	-.041	.494	-.0804	.117	-.684	
MISSGRAD missing on grade variables	.019	.711	.0600	.162	.370	
ınstant)		.875	.0445	.282	.158	

This model suggests that the following factors are significantly related to the level of technology uses by students.

Exploration and Getting Help

Our findings offer a critique of standard professional development practices. Of the technology exploration/exposure activities, attending district or school in-service programs and attending professional development conferences have the weakest associations with student use of computers (.068 and .013 respectively). Our findings also moderately support the standard diffusion literature that emphasizes changing the beliefs of potential innovators. Teacher beliefs about the value of computers are associated with a standardized coefficient of .1 while teachers' beliefs about the capacity of computers to help students essentially have a zero coefficient.

Our results suggest that teachers' adoption of computers is a function of individualized opportunities for experimentation and support. Of the exploration activities, time spent experimenting with district-supported software is by far the most important (standardized coefficient of .192). After this, reading journals, seeking help from others and independently exploring new technologies have moderate to low associations with student use of computers. But we note that more important than seeking help is the help received, and the relationship between supplier and receiver of help. In particular, receiving help from district and school colleagues has a coefficient of .1, essentially equivalent to the impact of beliefs of a teacher regarding value of computers. Help from a colleague is more than twice as important as help from a non-colleague (coefficient of .042). Presumably this is because the colleague understands the teacher's context and can provide customized, and thus trusted, support and feedback.

Teacher's Orientation

One of the strongest associations in our model is for the extent to which the teacher reported that computers complemented her style (standardized coefficient of .117). This

suggests that teachers are thoughtful professionals, implementing technology when it is consistent with their practice that has been honed for their specific context.

Innovation Competition

One surprising finding was that teachers who reported that their school tried to introduce many new things were much less likely to report their students using computers (standardized coefficient of -.116). This challenges the notion of teachers generally being innovators or not. Instead, innovations may compete with one another.

Teacher's Structural Location

The baseline teacher context is defined by the subjects and grades the teacher teaches and the district in which the teacher teaches. Those who teach higher grades and who report teaching English are more likely to report student use of computers. Furthermore, about 15% of the variation in student use of computers can be attributed to districts (District effects are: District C < District B < District D < District A). This is virtually all of the variation among schools. That is, all of the schools within a district are statistically identical in student computer use. Of course, the bulk of the variation is within school.

Unimportant factors

We explored a number of other factors (see survey instrument for possibilities) for their associations with student computer use. Many were discarded because they were neither of theoretical interest nor had a statistical impact on the student use of computers. We left a few factors in the model to establish that they were not associated with student use of computers, *once controlling for other characteristics*. These were teacher's perceived use of the value of computers for students, the pressure teachers perceive to use computers, and expertise of teacher

(as measured by number of others the teacher helps and a teacher's capacity to solve technical problems).

In particular we felt we needed to control for technical capacity before interpreting the association between help received and use because there are some teachers who are high users but receive little help because they themselves are experts. Indeed, the coefficients for help received increased once controlling for expertise of the teacher. In the next model we use the same theoretical framework to explore factors associated with teachers' uses of technology.

Factors Affecting Technology Uses by Teachers

Table 18. Model of Teacher Use of Computers

	Standardized Coefficients	Sig	B	Std. Error	t
Perceived Pressure to Use Computers					
PRESCOMP pressure to use computers (q26c,q26d)	.091	.034	.0684	.032	2.131
Exploring Technology Uses					
Q22A explore new technologies on my own	**.149**	.003	.1586	.053	2.965
Q22B attend district or school in-service programs for new tech	.036	.451	.0677	.090	.754
Q22C experiment with district-supported software	.094	.072	.0975	.054	1.807
Q22D seek help from others	.049	.289	.0627	.059	1.062
Q22E attend professional development converences about new tech	-.006	.894	-.0104	.077	-.134
Q22F read prof journals about new tech	-.028	.561	-.0357	.061	-.581
Q22G consult technology manuals	.059	.225	.0693	.057	1.217
Help received					
WRKHELP district and school help, accnt for source	-.014	.756	-.0006	.002	-.311
Beliefs About Value of Computers					
HELPME computers can help me as a teacher (q20)	**.136**	.028	.1473	.067	2.205
HELPSTU computers can help students (q21)	-.068	.225	-.0878	.072	-1.214
Technical Capacity/Expertise					
ISOLVE solves technical problems on own (q5,q11)	.034	.427	.0319	.040	.795
OUTHELP amount of help provided to others	.030	.484	.0096	.014	.700
Teacher=s Orientation					
COMPLEM computers complement my teaching style (q19 c-e+g+i)	**.162**	.003	.1694	.057	2.969
Structural Location					
Q31 Years in teaching?	**-.165**	.000	-.0164	.004	-3.982
ROCKFORD	.165	.018	.3241	.136	2.386
GRANDL	.081	.214	.1805	.145	1.244
BULLOCK	-.016	.773	-.0446	.155	-.288

		Technology Uses in Schools			
Q27SC1 Do you teach science	-.099	.124	-.1965	.128	-1.540
Q27SO1 Do you teach social studies	.165	.009	.3275	.125	2.614
Q27EN1 Do you teach english	.048	.494	.1006	.147	.685
Q27MATH Do you teach math	.057	.428	.1215	.153	.794
GRADE grade teacher teaches	**.103**	.117	.0459	.029	1.570
MULTGRAD teaches multiple grades	-.002	.979	-.0044	.166	-.027
MISSGRAD missing on grade vars	**.127**	.030	.4666	.214	2.184
(Constant)		.046	.6885	.344	2.002

The following factors are found to be significantly associated with teacher use of technologies:

Exploration, Changing Beliefs and Responding to Pressure,

As was true for student uses, our findings offer a critique of standard professional development practices. Of the technology exploration/exposure activities, attending district or school in-service programs and attending professional development conferences have the weakest associations with student use of computers (.036 and -.006 respectively). We find ample support for the standard diffusion literature that focuses on the beliefs of potential innovators. Teacher beliefs about the value of computers are associated with a standardized coefficient of .136 while teacher's beliefs about the capacity of computers to help students essentially has a zero coefficient.

Our results suggest that teachers' adoption of computers is very much a function of individualized opportunities for experimentation and a response of the individual to the social context. Of the exploration activities, exploring new technologies on one's own and experimenting with district supported software are by far the most important (standardized coefficients of .149 and .094 respectively). Teachers also respond to the pressure of their colleagues (standardized coefficient of .091). When teachers believe that colleagues expect them to use computers and that they must use computers to keep up in the school they increase their use of computers. But note the contrast with reported *student* uses that were responsive to help but not to pressure. This contrast draws form the the standard diffusion literature that typically does not recognize the complexities of students as a raw material and product. Therefore the standard model applies better to teacher implementation not directly associated with students.

Teacher's Orientation

As was the case for reported student uses, one of the strongest associations in our model is for the extent to which the teacher reported that computers complemented her style (standardized coefficient of .162).

Teacher's Structural Location

The baseline teacher context is defined by the subjects and grades the teacher teaches, the teacher's seniority, and the district in which the teacher teaches. Those who teach higher grades and who are junior are more likely to report use of computers. The ordering of the subjects is Science < English < Math < Social Studies. It is interesting to note that while the students of English teachers use computers the most, the teachers themselves use computers relatively little. Furthermore, about 10% of the variation in student use of computers can be attributed to districts (District effects are: District A < District C < District B < District D). This is virtually all of the variation among schools. That is, all of the schools within a district are statistically identical in student computer use. The bulk of the variation is within school. Note that District A had the highest student teacher uses and the lowest teacher uses, suggesting that teacher and student uses are influenced by independent district factors.

Summary of Key Findings

To summarize, the study found the following:

1. The level of technology uses in these sampled schools is higher than or comparable to the national average in terms of frequency of uses. Nearly 70% of teachers reported using lab computers on a weekly or daily basis, while nearly 90% use computers in their classrooms weekly or daily. Nearly 90% of teachers reported using emails weekly or daily while over 70% use the web weekly or daily.

2. However when the types of uses are considered, the situation is less encouraging. In most cases, the frequent uses are limited to teacher functions instead of student activities. For example, while over 50% of teachers reported that they use computers weekly or daily to communicate with parents and prepare for instruction, 73% of teachers reported that computers were never used for student to student communication. Nearly half of the teachers reported they never used computers for student inquiry activities. The most frequent student uses of computers are for developing basic computer skills.
3. There was significant change and anticipated change in the uses of technology. A majority of the teachers reported that their uses of computers increased significantly and plan to increase even more in the future.
4. Teachers' technology using experiences both in the lab and classroom have been positive. The majority (over 75%) reported that they experienced some technical problems in less than 25% of the times they used computers. And over 60% of the teachers said that these problems were addressed in an acceptable time frame.
5. In general, teachers were positive about computers and did not feel intimidated by computers. About 85% of the teachers felt that they could learn new computer applications quickly and over 50% thought computers are flexible and can be used to support their teaching style. Around 70% of teachers felt that computers can help them integrate different aspects of the curriculum, teach innovatively, direct student learning, model an idea or activity, connect the curriculum to real world tasks, and be more productive. Similarly, they believed that computers are valuable in helping students develop new ways of thinking, think critically, gather and organize information, explore a topic more deeply, be more creative, and be more productive.
6. School organized professional development opportunities were not frequent. About 5% of teachers reported never attending and 70% reported attending only once a year district or school organized inservice programs for learning new technologies.

However, many more teachers reported that they engaged in self-exploration with new technologies or district provided software monthly or weekly. It is also a common phenomenon for teachers to seek help from their colleagues.

7. While nearly 60% of teachers felt that the computer resources in their rooms were adequate for their instructional needs, only around 30% of teachers felt the resources are adequate for student uses. Similarly only one third of teachers felt it was easy to implement software or new hardware in their schools.
8. About 60% of teachers felt that they had access to sufficient and reliable hardware. A similar portion of teachers felt the same way about software. What's worth mentioning is that only a small fraction of teachers felt that schools and districts adequately involved teachers in decisions about software selection.
9. Many teachers felt the pressure to use computers. Nearly 60% of teachers reported that others expect them to use technology.
10. There is support for factors emerging from each level of our model. Usage varies by district that captures many of the effects of the adequacy of resources. Teachers' teaching styles and attitudes towards computers influence use, and these attitudes can be influences by social institutions far outside the district borderline. But we wish to emphasize that many of the components that affect technology inhere informal spaces of the school. In particular, the informal help and information teachers provide to each other have important associations with computer use that are comparable to the those of more commonly accepted factors. The informal social pressure that teachers exert on one another can also have a moderate effect on use. Finally, the play and experimentation that teachers engage in during cracks in the school day and outside of the school context are critical to technology implementation.

Ultimately, the informal, social organization of the school filters many of the effects on technology use. Teachers transmit and societal institutions through informal interactions as they make sense of external opinions and information and as

they exert pressure on one another to conform to internal norms. These interactions also shape beliefs about technology in particular, and teaching styles in general. The time that schools provide for unstructured experimentation and play give teachers an opportunity to consider, evaluate and attempt new applications to which they have been exposed outside the school.

The patterns of these informal processes vary within schools because teachers obtain help and are open to influences from different sources within schools. For example, in our findings, teachers were more strongly influenced by help from colleagues. Thus teachers who have different colleagues will have help resources likely resulting in different technology use. Furthermore to the extent that teachers are influenced by peers regarding teaching orientation and perceptions of computers. In other words, different peers will translate into different uses. Therefore the distribution of technology implementation is very much a function of the distribution of social processes within the school.

Implications

In drawing policy implications we note two important caveats. First, our sample is moderately more advantaged than the average elementary school in Michigan. Furthermore, our sampled schools come from only four districts, and, as we found that districts are the sources of variation among schools, we have a very small sample of a key source of variation. Second, we analyzed cross-sectional data. Thus we know many factors that are correlated with computer use, but any causal inferences are weak, and therefore policy implications should be cautious. That said, we endeavor to draw some preliminary policy implications.

Districts can influence 10-15% of computer use through the decisions they make to hire technology directors, provide resources, and establish a general vision for technology use, and this has non-negligible effects one computer usage. Thus districts should undertake these decisions carefully.

But most of the variation in implementation of computers is within schools. Thus we must focus on the teacher level factors that affect usage. The factors that are associated with computer usage map to four basic mechanisms for change: recruitment/selection, training/socialization, providing opportunities to explore and learn, and leveraging through the social context. First, teacher characteristics such as years teaching and the extent to which computers complement the teaching style are important predictors of computer usage. But the most likely mechanism for affecting changes in this category is through attrition and recruitment/selection. The clear policy implication is to consider how adaptable a teacher will be to planned technologies in hiring new teachers.

Second, change agents can provide training opportunities such as through in-service and professional development conferences. But our evidence suggests that these activities may have little effect on usage in the classroom for the common teacher. Most likely they operate through socializing teachers into different beliefs regarding the value of technology.

Third, change agents can provide various opportunities to explore and learn about new technologies. These have surprisingly strong effects on both teacher and student use of computers. This suggests that districts could do well simply to allow teachers release time to engage technology and consider its applications in *within their specific* contexts.

Fourth, change agents can leverage change through the social context. By giving teachers opportunities to help one another and to interact, schools may be able to increase the overall level of technology use. But leveraging through the social context is a double-edged sword. As help is most important when coming from a colleague, those with few colleagues may not be able to access the type of help they need to implement computers. Also, social pressure can be as strong a force working against technology as in favor of technology. This suggests that change agents should be very aware of the social structures and the school cultures in which they operate, and should deliberately address shortcomings and pitfalls. This recommendation is also consistent with the finding that teachers implement computers less when they are asked to

implement many other new things. Thus change agents should be aware of the stress on the social context and culture before attempting to implement further innovations.

Our findings suggest several programmatic possibilities. First, instead of spending time on in-service programs and conferences, districts could spend their resources giving teachers opportunities to explore computer applications. Encouragingly, teachers are already engaging in these types of behaviors relatively frequently, but it is uncertain how much of this activity is supported by districts. Second, teachers should be given time to help one another. Thus individualized release time for exploration may not be as helpful as group oriented activities such as a technology play-day including district support but with ample opportunity for teachers to help one another. But these interactions should be guided and focused on increasing levels of technology use. Third, schools that try to adopt multiple innovations simultaneously may find that none are fully implemented. Thus schools should limit the number of innovations they try to implement and devote ample resources on those they do choose.

These proposals can be summarized as:

1. Consider teaching style as it complements computer usage when hiring teachers.
2. Give teachers opportunities to experiment with software and demonstrated applications;
3. Consider providing opportunities for teachers to interact instead of standard professional development;
4. Focus on a small number of innovations at any given time.

References

Anderson, R. E., & Ronnkvist, A. (1999). *The Presence of Computers in American Schools* (http://www.crito.uci.edu/tlc/findings/computers_in_american_schools/). Irvine, CA: Center for Research on Information Technology and Organizations (CRITO) University of California, Irvine.

Becker, H. J. (2000a). Findings from the Teaching, Learning, and Computing Survey: Is Larry Cuban Right? *Education Policy Analysis Archives, 8*(51), 2-32.

Becker, H. J. (2000b). Who's Wired and Who's Not: Children's Access to and Use of Computer Technology. *The Future of Children, 10*(2), 44-75.

Bromley, H. (1998). Introduction: Data-driven Democracy? Social assessment of educational computing. In H. Bromley & M. Apple (Eds.), *Education, Technology, Power* (pp. 1-28). Albany, NY: SUNY Press.

Bruce, B. C. (1993). Innovation and Social Change. In B. C. Bruce & J. K. Peyton & T. Batson (Eds.), *Network-based Classrooms* (pp. 32). Cambridge, UK: Cambridge University Press.

Burbules, N. C., & Callister, T. A. (2000). *Watch It: The Risks and Promises of Information Technologies for Education*. Boulder, CO: Westview Press.

Cattagni, A., & Farris, E. (2001). *Internet Access in U.S. Public Schools and Classrooms: 1994 – 2000*. Washington DC: National Center for Educational Statistics.

Cohen, D. K. (1987). Educational technology, policy, and practice. *Educational Evaluation and Policy Analysis, 9*(2), 153-170.

Collins, A. (1996). Whither Technology and Schools? Collected Thoughts on the Last and Next Quarter Centuries. In C. Fisher & D. C. Dwyer & K. Yocam (Eds.), *Education and Technology: Reflections on Computing in Classrooms* (pp. 51-66). San Francisco, CA: Jossey-Bass.

Cuban, L. (1986). *Teachers and machines: The classroom uses of technology since 1920*. New York: Teachers College Press.

Cuban, L. (1996, October 9, 1996). Techno-reformers and Classroom Teachers. *Education Week on the Web, 16*.

Cuban, L. (1999, August 4, 1999). The Technology Puzzle: Why Is Greater Access Not Translating Into Better Classroom Use? *Education Week*, pp. 68, 47.

Cuban, L. (2001). *Oversold and Underused: Computers in Schools 1980-2000*. Cambridge, MA: Harvard University Press.

Hadley, M., & Sheingold, K. (1993). Commonalities and distinctive patterns in teachers' integration of computers. *American Journal of Education, 101*(May 1993), 261-315.

Hawkins, J., & Sheingold, K. (1986). The beginning of a story: Computers and the organization of learning in classrooms. In J. A. Culbertson & L. L. Cunningham (Eds.), *Microcomputers and Education: Eighty-fifth Yearbook of the National Society for the Study of Education* (pp. 40-58). Chicago: Universty of Chicago Press.

Hodas, S. (1993). Technology refusal and the organizational culture of schools. *Educational Policy Analysis Archives, 1*(10).

International Society for Technology in Education. (2000). *National Educational Technology Standards*. Eugene, OR: International Society for Technology in Education.

Literacy, C. o. I. T., Board, C. S. a. T., & Commission on Physical Sciences, M., and Applications. (1999). *Being Fluent with Information Technology*. Washington DC: NATIONAL ACADEMY PRESS.

Lortie, D. (1975). *Schoolteacher*. Chicago: University of Chicago Press.

Loveless, T. (1996). Why aren't computers used more in schools? *Educational Policy, 10*(4), 448-467.

Means, B. (1994). Introduction: Using Technology to Advance Educational Goals. In B. Means (Ed.), *Technology and Education Reform* (pp. 1-21). San Francisco: Jossey-Bass.

Merrow, J. (1995, March 29, 1995). Four Million Computers cannot be Wrong! *Education Week*, pp. 52.

Papert, S. (1993). *The children's machine: rethinking school in the age of the computer*. New York: BasicBooks.

Papert, S. (1998, June 2, 1998). *Child Power: Keys to the New Learning of the Digital Century*. Paper presented at the The 11th Colin Cherry Memorial Lecture on Communication, Imperial College, London.

Papert, S. (1999). Technology in Schools - To Support the System or Render it Obsolete? *Milken Exchange [Available online at: http://www.milkenexchange.org/article.taf?_function=detail&Content_uid1=106]* .

Prasad, P. (1993). Symbolic processes in the implementation of technological change: A symbolic interactionist study of work computerization. *Academy of Management Journal, 36*(6), 1400-1429.

President's Committee of Advisors on Science and Technology (Panel on Educational Technology). (1997). *Report to the President on the Use of Technology to Strengthen K-12 Education in the United States*. Washington, DC: President's Committee of Advisors on Science and Technology.

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: Free Press.

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing How and What Children Learn in School with Computer-based Technologies. *The Future of Children, 10*(2), 76-101.

Sandholtz, J. H., & Ringstaff, C. (1996). Teacher Change in Technology-rich Classrooms. In C. Fisher & D. C. Dwyer & K. Yocam (Eds.), *Education and Technology: Reflections on Computing in Classrooms* (pp. 281-299). San Francisco: Jossey-Bass.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with Technology: Creating Student-Centered Classrooms*. New York: Teachers College Press.

Smerdon, B., Cronen, S., Lanahan, L., Anderson, J., Iannotti, N., & Angeles, J. (2000). *Teachers' Tools for the 21 st Century: A Report on Teachers' Use of Technology*. Washington DC: National Center for Educational Statistics.

Tyack, D. B., & Cuban, L. (1995). *Tinkering toward utopia : a century of public school reform*. Cambridge, Mass.: Harvard University Press.

U.S. Department of Education. (2000). *eLearning: Putting a World-Class Education at the Fingertips of all Children*. Washington DC: US Department of Education.

US Congress Office of Technology Assessment. (1995). *Teachers and Technology: Making the Connection* (OTA-EHR-616). Washington DC: Office of Technology Assessemnt.

Worthington, V. L., & Zhao, Y. (1999). Existential Anxiety and Technological Changes: Two Factors Ignored in the Research on Computer Anxiety in the Past. *Journal of Educational Computing Research, 20*(4), 299-316.

Zhao, Y., Byers, J. L., Mishra, P., Topper, A. Cheng, H. J., Enfield, M., Pugh, K., Tan, S., Ferdig, R. (1999). *What do they know: A comprehesive portrait of technology using teachers* (Research Report). East Lansing: Michigan State University.

Zhao, Y., & Conway, P. (1999, April 19-23, 1999). *What is for sale today? A Analysis of State Educational Technology Plans.* Paper presented at the 1999 American Educational Research Association Annual Meeting, Montrel, Canada.

Zhao, Y., & Cziko, G. A. (20001). Teacher Adoption of Technology: A Perceptual Control Theory Perspective. *Journal of Technology and Teacher Education, 9*(1), 5-30.

Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. (in press). Conditions for Classroom Technology Innovations. *Teachers College Record*.